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# On-Field Quality Assessment of Ginger (*Zingiber officinale* cv. Moran), Native to Assam in Northeast India

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**ABSTRACT**

Ginger (*Zingiber officinale*) is an important industrial crop of India. Moran is an elite quality native ginger cultivar of Assam, known for its high content of oil, oleoresin, and bioactive compounds in the rhizomes. The present study discusses a simple on-field quality evaluation of Moran ginger cultivar grown at Tinsukia District of Assam, India. In this study, quality evaluation of the green rhizomes of organically grown Moran ginger cultivar was undertaken, using low-cost and commonly available chemicals like washing soda and iodine solution at the farmer's field location. Red colour development in the rhizome transverse sections after treatment with washing soda was observed to be more intense in case of the Moran ginger cultivar in comparison to the exotic Rio-de-Janeiro cultivar. Similarly, an intense blue colouration was observed in rhizome transverse sections of the Moran ginger cultivar post-treatment with iodine. The visual observations were further verified using the Trigit web-based Android mobile colour image processing application. Results of the on-field quality evaluation indicate a high content of flavonoids and starch in the Moran ginger rhizomes.

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## 1. Introduction

Ginger (*Zingiber officinale*) is a herbaceous perennial plant belonging to the Zingiberaceae family. It's characterized by a thick, branched rhizome (underground stem), aerial pseudo-stems (false stems formed by tightly wrapped leaf bases), and narrow, lance-shaped leaves. The plant produces cone-shaped flower spikes. Plenty of cultivars (cultivated varieties) exist around the world (Kizhakkayil and Sasikumar, 2011). The quality attributes of ginger cultivars, to a certain extent, depend upon the climate, soil, and local growing conditions (Sanwal *et al*., 2012). References to ginger are found in the maxims of Dak (*Dakar Bachan* in Assamese), which is one of the richest sources of oral literature and traditional knowledge in Assam, India. (Saikia, 2017). One of the earliest written references to the usage of the term Moran ginger ('*Moran Ada*' or '*Moran Aada'* in Assamese) is found in the first Assamese language dictionary published in the year 1867 from Sibsagar, Assam, compiled by American Baptist Missionary, Miles Bronson (Bronson, 1867). Historically, '*Moran Ada*' or '*Moran Aada*' derives its name from the area known as Moranhat, located in the eastern part of Assam or Upper Assam. Moranhat ('*hat*' or '*haat*' in Assamese) refers to a small marketplace (Mondal, 2021) set up by the people of Moran community (an indigenous Assamese community). Moranhat (a historically important area of Sibsagar) now falls in the Charaideo district in the Indian state of Assam. 'Moran' ginger (Saikia and Shadeque, 1992; Singh *et al*., 2024) also written and referred to as 'Maran' in scientific literature (Zachariah *et al*., 1993; Shamina *et al*., 1997) is a cultivated variety of common commercial ginger or true ginger i.e. *Z. officinale* Rosc. (Encyclopaedia Britannica, 2024) native (Akshitha *et al*., 2020) to the state of Assam (Kew, 2024) in NE India. Traditionally grown organic Moran ginger is known as '*Moran Ada'*

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or '*Moran Aada*' (*Vernacular Assamese*) amongst the local populace in Assam (Bronson, 1867). Moran is an elite quality ginger variety having a total gingerol content of >1.5% w/w or more, in its rhizomes (Saikia and Shadeque, 1992; Akshitha *et al*., 2020; NAIP-ICAR, 2025). The Moran ginger variety has been used since time immemorial in the traditional medicine and food preparations of Assam. Moran ginger is sold in local markets mainly in its green (fresh) form and it is also highly amenable to preparation of dried ginger (Ali, 2007). In Assam (India), as in most Asian countries, fresh ginger is produced and consumed locally (Gogoi and Priyadharshini, 2021). Moran ginger is generally sold as raw ginger in local markets, although it is possible to transport fresh roots internationally as a fresh vegetable from the area of production. It is also likely that a part of the high-quality fresh ginger produce from the farmer's field from remote locations of Assam in Northeast India, also find its way to ginger processing and traditional commercial hubs located in other parts of India such as Cochin (Kochi) and Calicut (Kozhikode) (Lambert, 1805; Gogoi, 2020). Due to the inherent varietal property of high dry recovery, Moran and other high dry recovery ginger varieties of North-East India (Ali, 2007) are a much sought-after raw material for preparation of dry ginger and oleoresins for export and domestic markets. The traditionally grown organic Moran ginger variety cultivated in Assam has been able to preserve its unique identity and appeal in the spice markets due to its superior inherent quality attributes (Babu *et al*., 2021; Dutta and Kakati, 2023).

The relative paucity of sophisticated spice quality evaluation laboratories and quality standards for fresh (green) ginger are some of the hurdles faced by the farmers cultivating Moran ginger in the pristine natural habitats of Assam in North-East India for bringing a quality produce for sale in the domestic and international markets. Simple methodologies for quality evaluation of the farmers' produce near the site of cultivation, in a timely manner, are vital for allocation of their scarce resources and agri-horti inputs for efficient post-harvest management of green ginger rhizomes for sale in domestic and international markets during peak demand period. The present study therefore attempts to document the distinct (morphological) characteristics of the Moran ginger cultivar and to develop a simple field methodology for rapid evaluation of the quality of fresh Moran ginger rhizomes after their harvest in the farmer's fields in Assam, India.

## 2. Materials and methods

### *2.1. Organic ginger cultivars (rhizomes)*

Rhizomes of Moran ginger (*Z. officinale* Rosc.), a traditionally grown organic cultivar native to Assam, were collected in March 2024 from a farmer's field in Santipur 7 village, Tinsukia District, Assam (Fig. 1). The field is managed by the Abohtani Agro Producer Company Limited, a Farmer Producer Organization. For comparative analysis, rhizomes of the Rio-de-Janeiro cultivar (an exotic ginger variety) were simultaneously harvested under identical conditions. On-field quality assessments were conducted at the same location (Fig. 2).

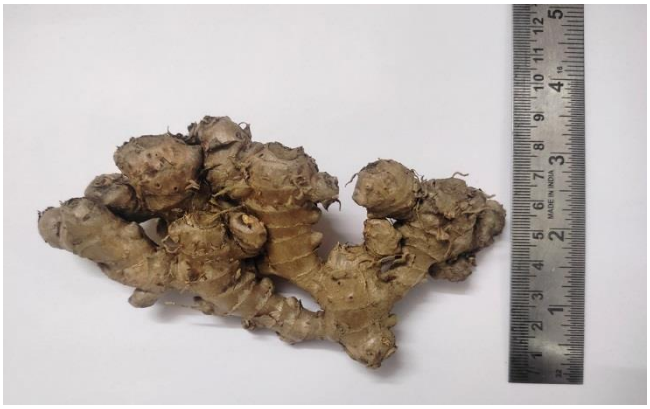

**Figure 1. Rhizome of ginger cultivar Moran**

**Figure 2. Farmer's Field location (March 2024)**

### *2.2. Chemicals and reagents used in on-field quality evaluation*

Washing Soda (Soda Ash) (Brand Vitszee, 500 gm pack, Zvee Chem. & Eng. Trading Company, Ahmedabad, Gujarat) and Iodine Solution 1% (Brand Spectrum, 125 ml pack, Spectrum Reagents and

Chemicals, Edayar, Kerala) were procured from the local market in Chapakhowa (Sadiya), Tinsukia District, Assam. A stainless-steel knife (Brand Ace, Glare Cutlery Pvt Ltd, Rajkot, Gujarat) was used for sectioning the ginger rhizomes.

### *2.3. Field-based quality evaluation of ginger rhizomes*

#### *2.3.1. Visualization assay for flavonoid-like compounds using washing soda (Soda ash)*

Two teaspoons (≈10 g) of Washing Soda were added to 90 ml of tap water (measured using plastic measuring cups of medicine bottles) available in the field site and volume was made up to 100 ml to make a 10% w/v washing soda solution. 1-2 mm thick transverse sections of the ginger rhizomes of both Moran and Rio-de-Janeiro cultivars were cut using an aluminium kitchen knife after peeling the outer skin. These transverse sections were dipped in the washing soda solution. After 30 minutes, the ginger rhizome sections were taken out and observed for colour change. Photographs of the sections against a white paper background were taken using smartphone camera (Redmi Note 10, Model M2101K7AI, Xiaomi Technology India Private Limited, Bengaluru, Karnataka).

#### *2.3.2. Visualization assay for starch using iodine solution*

1-2 mm thick transverse sections of the ginger rhizomes of both Moran and Rio-de-Janeiro cultivars were cut using aluminium kitchen knife after peeling the outer skin. A drop of Iodine Solution 1% was put in the ginger rhizome transverse sections. Visualization of the presence of starch in the ginger tissues is indicated by dark blue colouration upon application of Iodine. The rhizome transverse sections were observed for colour change. Photographs of the sections against white paper background were taken using smartphone camera (Redmi Note 10, Model M2101K7AI, Xiaomi Technology India Private Limited, Bengaluru, Karnataka).

#### *2.3.3. Colorimetric analysis of smartphone captured images*

The photographs of the ginger rhizome transverse sections treated with Washing Soda and Iodine Solution 1% were further analysed using Android smartphone accessible Trigit (Tjandra *et al*., 2023), a free, rapid, and user-friendly web application to quantify colour signals from images. The analysis was carried out using the auto-selection feature of the web application with 50% sensitivity.

## 3. Results and discussion

### *3.1. Morphological characteristics of ginger cultivar Moran*

The distinct morphological characteristics of ginger cultivar Moran that have been reported in scientific literature are summarized in Table 1. The distinct morphological characteristics of Moran ginger cultivar reported in Table 1 are based on field trials conducted in various regions of India. The Moran cultivar of ginger, also referred to as ‘Maran’, is a key native cultivar from Assam in NE India. It was studied extensively for ginger varietal improvement initiatives through modern plant breeding techniques in India since the 1970s onwards (Nybe, 1978). The dichotomy introduced by the written spelling of this indigenous variety of Assam i.e. the name ‘Moran’ (Singh *et al*., 2024) also written and referred to as ‘Maran’ in scientific literature (Babu *et al*., 2021) and the complexities of taxonomic classification of *Zingiberaceae* (the ginger family) through traditional (morphology) and modern genetic characterization based on homology of biomolecule sequences with only available sequence data in genetic databanks has led to some erroneous identification / classification (Das, 2011; Hazarika *et al*., 2020), source (origin) misrepresentations (Kizhakkayil and Sasikumar, 2011; Ravindran and Babu, 2016; Vedashree and Madhava 2023). The guidelines for the conduct of tests for distinctiveness, uniformity and stability on ginger grown in India were released by the Protection of Plant Varieties & Farmers’ Rights Authority, Government of India (PPV and FRA, 2007). Subsequent workers taking these guidelines have re-affirmed the unique morphological characteristics of Moran (Maran) ginger cultivar (Akshitha *et al*., 2019; Babu *et al*., 2019; Singh *et al*., 2024).

Akshitha et al. (2019) and Singh et al. (2024) have categorized Moran ginger cultivar to have few (<10 nos.) tillers, based on observation of the plant growth after 150 days after planting. However, Babu et al. (2019) categorized Moran ginger cultivar to have many numbers of tillers i.e. (>15 nos.), based on observation of the plant growth after 180 days after planting. This

reported character of Babu et al. (2019) is in agreement with the findings of Nybe (1978), who also reported many tillers (>15 nos.) after observation of the plant growth after 255 days after planting (Table 1). Interestingly, Moran ginger cultivar is categorized as having a medium crop duration (200-210 days) by PPV and FRA (2007), while the findings of Nybe (1978) reveal Moran ginger cultivar to belong to ginger varieties with a long crop duration i.e., >210 days (Table 1). Further, while Moran ginger has been grouped into cultivars giving medium (16-18%) dry recovery post-harvest by PPV and FRA (2007), Akshitha et al. (2019) categorized Moran (Maran) ginger in the group of cultivars giving high (>18%) dry recovery (%) from rhizomes after harvest. (Table 1). PPV and FRA (2007) also specifically mention that colour of the bract tip of fully developed spike in case of Moran (Maran) ginger cultivar is yellowish white. This description of the bract tip of fully developed spike agrees with the description provided for flower of *Z. officinale* Rosc. by Encyclopaedia Britannica (2024) which states 'The flowers are in dense conelike spikes about 2.5 cm (1 inch) thick and 5 to 8 cm (2 to 3 inches) long that are composed of overlapping green bracts, which may be edged with yellow' (Encyclopaedia Britannica, 2024). Differences in flowers of *Z. officinale* Rosc. (true ginger) and *Z. zerumbet* (shampoo ginger) have been described by Rachkeeree et al. (2018). *Z. zerumbet* (shampoo ginger) is almost morphologically identical to *Zingiber montanum* (cassumunar ginger, synonym *Z. cassumunar*) in the non-flowering stage and molecular tools are often necessary for their identification (Ghosh *et al*., 2011). Development of expressed sequence tag (EST)-simple sequence repeat (SSR) markers based on transcriptome and its validation in 48 genotypes of ginger (*Z. officinale* Rosc.) by Vidya et al. (2021) reveals that Moran ginger cultivar falls in Cluster IB with 13 other genotypes. Further, it is interesting to note that the 48 genotypes formed three clusters Cluster I (sub-subdivided into four sub-clusters IA, IB, IC and ID), Cluster II (containing all seven red ginger genotypes in the study) and Cluster III (*Z. zerumbet*) (Vidya *et al*., 2021).

**Table 1. Distinct characteristics (morphological) of Moran ginger cultivar native to Assam, India**

| Descriptor | Distinct characteristics | Reference publication(s) |
|---|---|---|
| Growth habit | Erect | Akshitha et al. (2019) |
| Plant height | Short (<100 cm) | Nybe (1978); Akshitha et al. (2019); Babu et al. (2019); Singh et al. (2024) |
| Shoot diameter | Narrow (<3 cm) | Akshitha et al. (2019) Singh et al. (2024) |
| Number of Tillers (after 150 days after planting DAP) | Few (<10 nos.) | Akshitha et al. (2019) Singh et al. (2024) |
| Number of Tillers (after 180 DAP) | Manym (>15 nos.) | Babu et al. (2019) |
| Number of Tillers (after 255 DAP) | Manym(>15 nos.) | Nybe (1978) |
| Number of leaves on main shoot or Tiller | Few (<25 nos) | Nybe (1978); Akshitha et al. (2019); Singh et al. (2024) |
| Leaf length | Short (<25 cm) | Nybe (1978); Akshitha et al. (2019); Singh et al. (2024) |
| Leaf width | Narrow (<2.5 cm) | |
| Rhizome thickness | Medium (2-3 cm) | Akshitha et al. (2019) |
| Rhizome shape | Straight | Akshitha et al. (2019) |
| Dry recovery (%) from Rhizomes after harvest | Medium (16-18%) | PPV and FRA (2007) |
| | High (>18%) | Akshitha et al. (2019) |
| Colour of the bract tip of fully developed spike | Yellowish - white tip | PPV and FRA (2007) |
| Crop duration(days) | Medium (200-210 days) | PPV and FRA (2007) |
| | Long (>210 days ) | Nybe (1978) |

### *3.2. Field-based quality evaluation of ginger rhizomes*

#### *3.2.1. Visualization assay for flavonoid-like compounds using washing soda (Soda ash)*

A colour change from yellow to red was observed in the ginger rhizome transverse sections after treatment with 10% (w/v) washing soda solution for 30 minutes. The colour change in the rhizome transverse sections of Moran ginger cultivar appeared more intense than the red colour generated in the case of the exotic Rio-de-Janeiro cultivar (Fig. 3). The ginger rhizome (*Z. officinale* Rosc.) is known to show a pale-yellow colour. Iijima and Joh (2014), while studying 62 ginger cultivars collected from various prefectures of Japan elucidated that curcumin, demethoxycurcumin, and 6-

dehydrogingerdione were the three main yellow pigment compounds in ginger rhizomes. Further, they also noted that the profiles of these components in ginger rhizomes differed from those of *C. Longa* (turmeric) and the contents of these compounds were greater in mature rhizomes than in immature rhizomes (Iijima and Joh, 2014). In the present study, A colour change from yellow to red was observed in the ginger rhizome transverse sections after treatment with 10% w/v washing soda solution for 30 mins (Fig. 3).

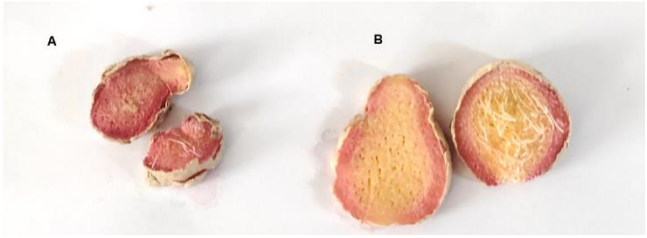


**Figure 3. Transverse sections of ginger rhizomes after treatment with washing soda (A) Moran cultivar ; (B) Rio-de-Janeiro cultivar.**

Change in colour from yellow to red in ginger tissue sections treated with a 10% (w/v) solution of sodium carbonate was reported by Mangalakumari et al. (1984). Zarate and Yeomen (1994) opined that the colour change from yellow cells to red in ginger tissue sections treated with sodium carbonate solution was due to the presence of curcumin derivatives and/or flavonoid-like compounds. They further concluded that flavonoids, phenolics (including gingerol), curcumin derivatives and the essential oils, characteristic of the spice, are accumulated and stored in the yellow cells (Zarate and Yeomen, 1994). The density of the yellow cells in ginger rhizome transverse sections observed under light microscope was found to vary with the ginger variety (Meadows *et al*., 2004).

Moran ginger cultivar in a recent study by Dutta and Kakati (2023), was found to have the highest flavonoid content (47.8 mg/g dry weight) in comparison to Jati and Nadia cultivars (Dutta and Kakati, 2023). In another study by Dhanik and Vivekanand (2017), the flavonoid content of five accessions of *Z. officinale* Rosc. from Kumaun and Garhwal region of Uttarakhand, India, namely Bana, Kapkot, Roorkee, Chamoli and Takula, was studied, in which Bana variety was reported to have the highest flavonoid content (38.87 mg $g^{-1}$ dry weight). Our on-site quality assessment in the farmer's fields, utilizing relatively cheap and easily available washing soda (source of sodium carbonate), indicates the high flavonoid content of the Moran ginger cultivar (Fig. 3).

*3.2.2. Visualization assay for starch using iodine solution 1%*

The presence of starch in the ginger tissues (rhizome transverse sections) after treatment with 1% iodine solution, indicated by rapid development of dark blue colouration (Fig. 4). The colour change in the rhizome transverse sections of Moran ginger cultivar appeared more intense than that generated in the case of the exotic Rio-de-Janeiro cultivar. The deep colouration covered the entire surface area of Moran ginger cultivar transverse section (Fig. 4).

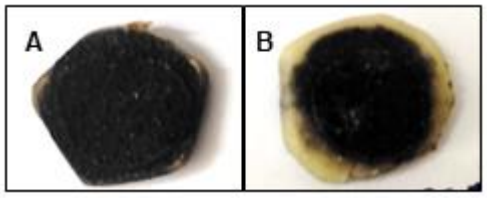


**Figure 4. Transverse sections of ginger rhizomes after treatment with Iodine solution. (A) Moran cultivar ; (B) Rio-de-Janeiro cultivar.**

The presence of starch in the ginger tissues (rhizome transverse sections) indicated by rapid development of dark blue colouration upon treatment with 1% iodine solution was observed in both transverse sections of Moran and the exotic ginger cultivar Rio-de-Janeiro (Fig. 4). A similar methodology of using iodine solution was used by Chittaragi et al. (2022) to visualize presence of starch grains in hand cut sections of ginger rhizomes with trinocular microscope (Chittaragi *et al*., 2022). Chittaragi et al. (2022) also reported that T.S of the seed rhizome remains the same throughout the storage period with slight variation. They further observed that the size of starch grains in the ginger rhizomes decreases after three months of storage, as the stored carbohydrate was utilized by seed rhizomes to initiate sprouting (Chittaragi *et al*., 2022). Starch accumulation in the inner part of the cortex and the stele is a plesiomorphic (ancestral) character in Zingiberales, while other types of starch accumulation in the rhizomes may be genus or species specific (Chomicki, 2013). In the present study, the colour change in the rhizome transverse sections of Moran ginger cultivar appeared more intense than that generated in the case of the exotic Rio-de-Janeiro cultivar. The deep colouration covered the entire

surface area of Moran ginger cultivar transverse section (Fig. 4). Rhizomes of *Z. officinale* Rosc. have been reported to contain starch between 40-60% w/w (Singh *et al*., 2017). Moran ginger rhizomes have been reported to have more than 40% starch based on conventional laboratory-based quality evaluation techniques (Sanwal *et al*., 2012). The on-field visual differences in the intensity of the dark blue colouration (Fig. 4) indicate that the Moran ginger rhizomes have more starch in comparison to the rhizomes of the exotic (introduction from Brazil) Rio-de-Janeiro cultivar grown in the same agro-climatic conditions.

### *3.2.3. Colorimetric analysis of smartphone captured images*

Colorimetric analysis of Fig. 3 using the Trigit web application revealed that the percentage of red colour (%R) was higher for Moran ginger cultivar in comparison to the percentage of red colour (%R) in the case of the exotic Rio-de-Janeiro ginger cultivar (Table 2). A screenshot of the web application along with the auto-selected areas (auto-generated PNGs) of the ginger rhizome transverse sections is provided in Fig. 5.

**Table 2. Colorimetric analysis for red colour of rhizome TS treated with washing soda**

| Ginger cultivar | %R | %G | %B |
|---|---|---|---|
| Moran | 0.44 | 0.30 | 0.26 |
| Rio-de-Janeiro | 0.40 | 0.32 | 0.27 |

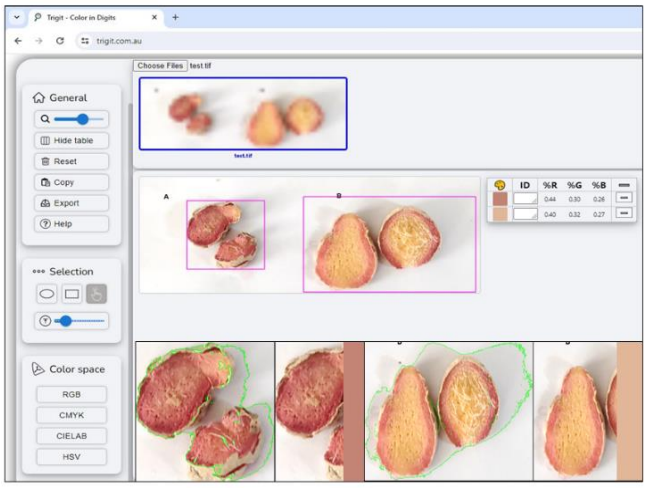


**Figure 5. Screenshot of colorimetric analysis in Trigit of rhizomes after treatment with washing soda. (A) Moran cultivar ; (B) Rio-de-Janeiro cultivar.**

Colorimetric analysis of Fig. 4 using the Trigit web application revealed that the percentage of blue colour (%B) was more for Moran ginger cultivar in comparison to the percentage of blue colour (%B) in the case of the exotic Rio-de-Janeiro ginger cultivar (Table 3). A screenshot of the web application, along with the auto-selected areas (auto-generated PNGs) of the ginger rhizome transverse sections, is provided in Fig. 6.

**Table 3. Colorimetric analysis for dark blue colour of rhizome TS treated with iodine.**

| Ginger cultivar | %R | %G | %B |
|---|---|---|---|
| Moran | 0.35 | 0.33 | 0.32 |
| Rio-de-Janeiro | 0.39 | 0.33 | 0.27 |

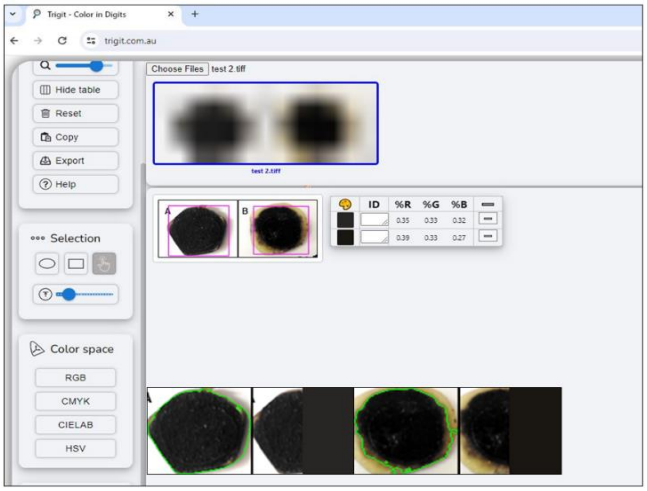


**Figure 6. Screenshot of colorimetric analysis in Trigit of ginger rhizomes after treatment with iodine. (A) Moran cultivar ; (B) Rio-de-Janeiro cultivar.**

Identifying colour changes via the naked eye has been a foundational aspect in scientific applications. Relying on human vision to detect colour changes is vital in unlocking the possibilities of low-cost, on-site testing, which bypasses the need for costly specialized laboratory instruments (Nguyen *et al*., 2020). Monitoring colour change has been used to identify abnormalities in health, environmental, water, agricultural, and food quality. Human vision is subjective as each person has slightly different numbers of photoreceptor cells, which changes the way colour is perceived. Therefore, in investigations where colour matching is required, objective colorimetric analysis is essential to prevent incorrect interpretations (Tjandra *et al*., 2023). Colorimetric analysis to quantify the on-field visual perceptions of colour change in the ginger rhizome hand cut transverse sections upon treatment with washing soda solution and commonly available iodine solution (Fig. 3 and 4) using the recently developed Trigit (Tjandra *et al*., 2023) free web application (Fig. 5 and 6), yielded results that are depicted in Tables 2 and 3. Colorimetric analysis in the

RGB colour space of Trigit revealed the percentage of red colour (%R) developed in Moran ginger cultivar treated area, to be 0.44 percent while, Rio-de-Janeiro recorded a red colour (%R) of 0.40 percent only upon treatment with washing soda (sodium carbonate) solution (Table 2). Colorimetric analysis in the RGB colour space of Trigit of the image captured for the iodine assay (Fig. 4) revealed that the percentage of blue colouration (%B) to be 0.32 percent for the Moran ginger cultivar while, Rio-de-Janeiro recorded a blue colour (%B) of 0.27 percent only (Table 3). Results obtained in the current investigation using the intuitive Trigit auto-selection tool demonstrate that it is possible to quantity visual perception in complex shapes (ginger rhizome transverse sections). The on-site colorimetric analysis (carried out in android smartphone) results agree with our visual estimation of colour change (Fig. 3 and 4) and indicate towards the high content of flavonoids and starch in the Moran ginger cultivar rhizomes in comparison to the exotic Rio-de-Janeiro ginger cultivar.

## 4. Conclusion

Results obtained in the current investigation indicate a high content of flavonoids and starch in the Moran cultivar of ginger. The Moran cultivar, native to Assam in Northeast India, based on its quality characteristics, is therefore an ideal candidate for Geographical Indication (GI) protection. To the best of our knowledge, this is the first report of an on-field quality evaluation of the high-quality organically cultivated native ginger cultivar Moran of Assam, India. The field-based approach for quality evaluation described in the present investigation is likely to be beneficial for developing simple techniques for ginger quality evaluation in the farmer's field. In the global context also, a move towards fast and cost-effective means for on-farm qualitative and quantitative determination of quality attributes of unique ginger cultivars is envisioned in the future, with the help of portable near-real-time colour image processing technologies.

## Conflict of interests

All authors declare no conflict of interest.

## Ethics approval and consent to participate

No humans or animals were used in the present research. The authors have adhered to ethical standards, including avoiding plagiarism, data fabrication, and double publication.

## Consent for publications

All authors read and approved the final manuscript for publication.

## Availability of data and material

All the data are embedded in the manuscript.

## Authors' contributions

All authors had an equal role in study design, work, statistical analysis and manuscript writing.

## Informed consent

The authors declare that no patients were used in this research.

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